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- (54) **STATELESS FLEXIBLE BOOT CONTROL**
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**H04L 29/12** (2006.01)

(52) **U.S. Cl.**  
CPC ..... **H04L 41/0893** (2013.01); **G06F 9/441** (2013.01); **G06F 9/4408** (2013.01); **G06F 9/4416** (2013.01); **H04L 61/2023** (2013.01)

(58) **Field of Classification Search**  
CPC . G06F 9/4406; G06F 9/4408; G06F 11/2053  
See application file for complete search history.

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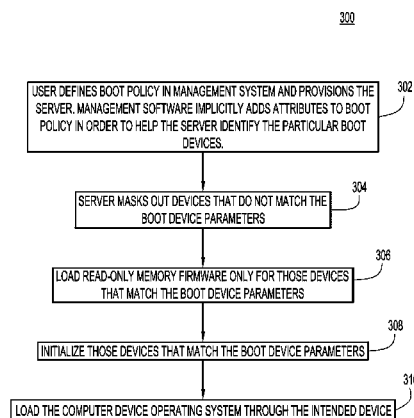
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(57) **ABSTRACT**

Techniques are provided herein for optimizing boot order for devices in a data center environment. These techniques may be embodied as a method, apparatus and instructions in a computer-readable storage media to perform the method. A computing apparatus having connectivity to a network receives instructions from a management device in the network. The instructions comprise attributes that are associated with boot devices hosted by the computing apparatus. The attributes are analyzed to determine a priority order for the boot devices. One or more boot devices hosted by the computing apparatus is removed from an initialization process when the one or more boot devices do not match the attributes in the instructions. The remaining boot devices, other than the one or more boot device removed from the initialization process, are initialized in accordance with the priority order.

**20 Claims, 4 Drawing Sheets**



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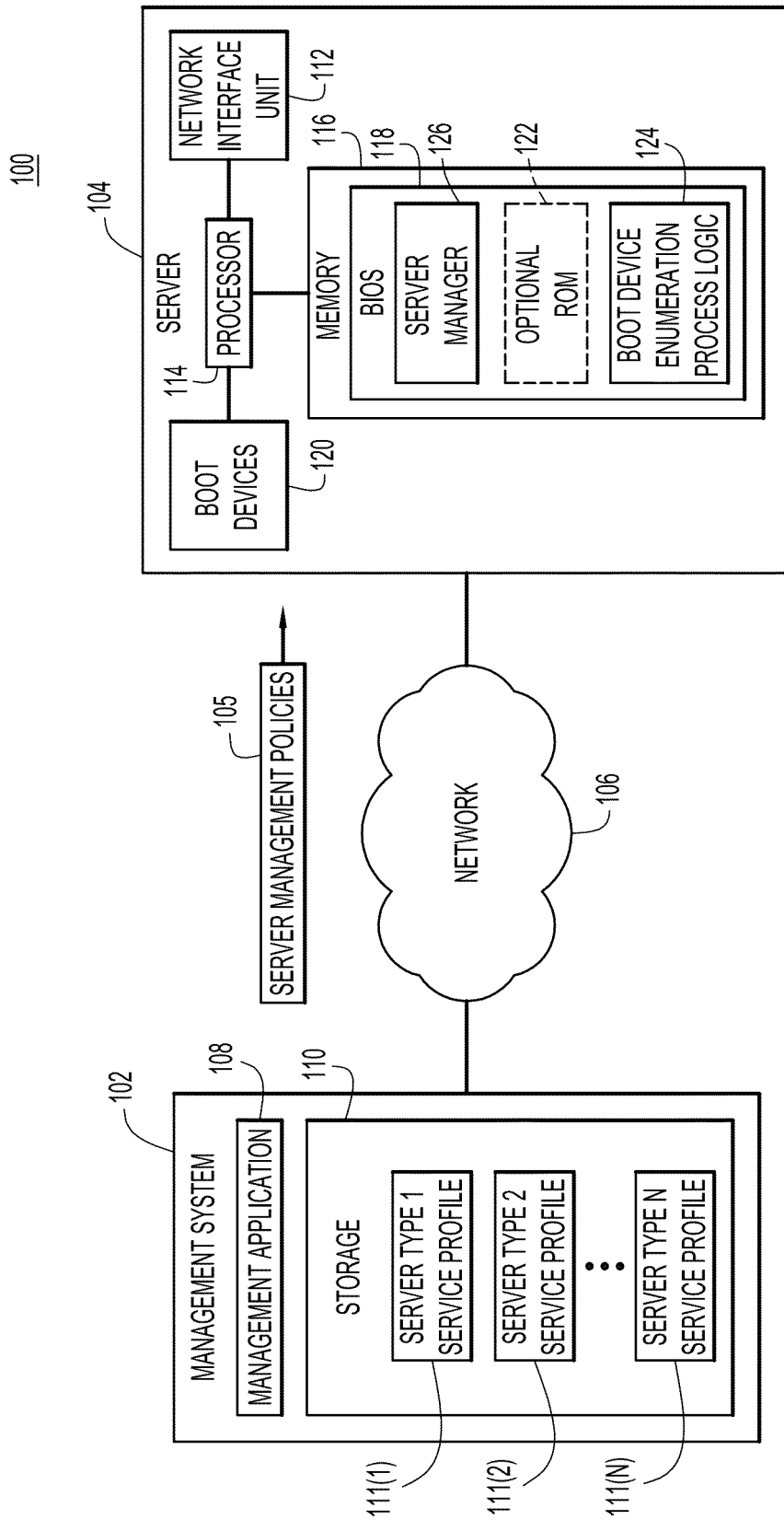


FIG.1

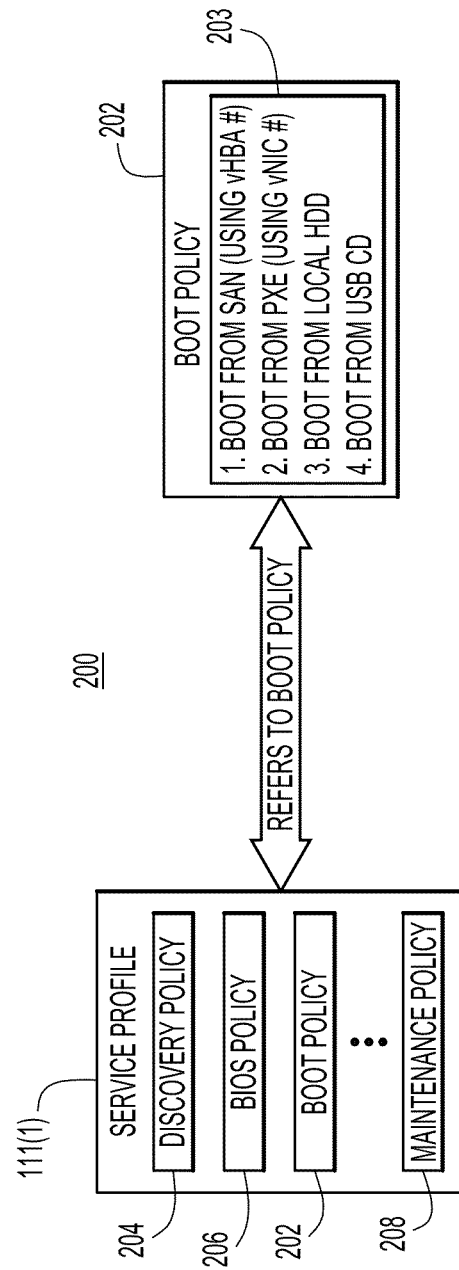


FIG.2

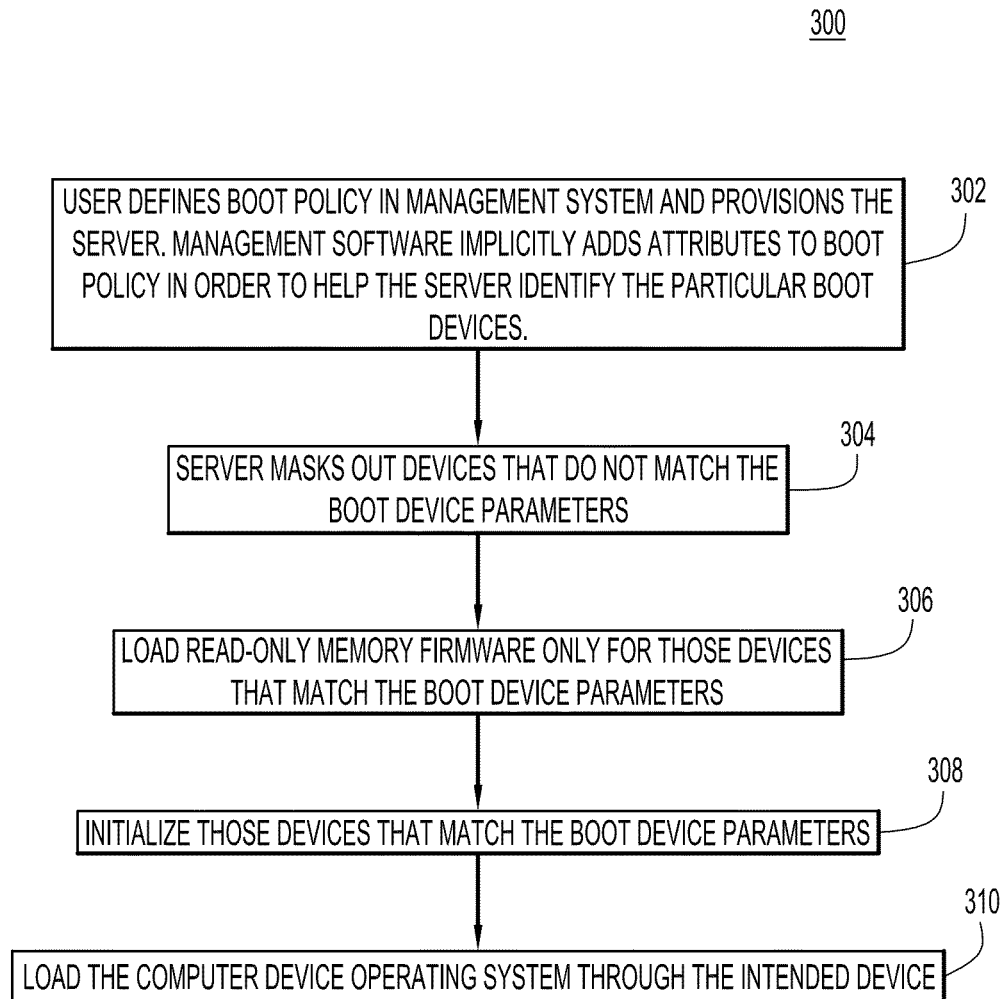


FIG.3

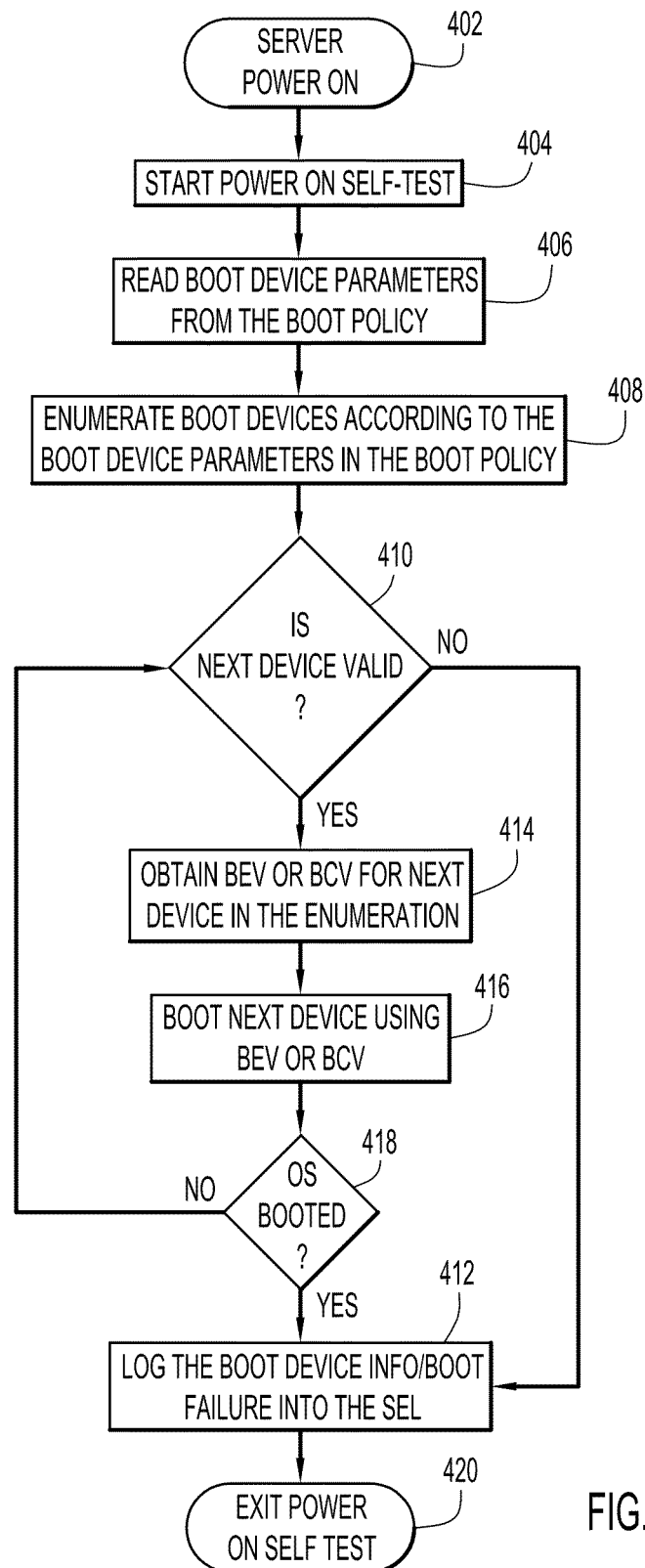


FIG.4

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## STATELESS FLEXIBLE BOOT CONTROL

## TECHNICAL FIELD

The present disclosure relates to optimizing boot order 5  
control for devices in data center environments.

## BACKGROUND

In data center environments, a server may boot or reboot 10  
devices that it hosts, for example, to load or reload an operating system. The server may maintain a boot list that specifies a particular boot order for device types. The boot list may be utilized by a basic input/output system (BIOS) of the server to instruct the devices hosted by the network to 15  
boot or “turn on” in a particular order. The BIOS of the server is also configured to check the memory capacity of the server to ensure that the devices hosted by the server are able to boot. The speed at which the server is able to load or reload an operating system depends on the device types that 20  
are in the boot list. When the boot list is optimized, the operating system of the server can load more quickly.

## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows an example data center environment with a management system that sends server management policies to a server for optimizing boot order control.

FIG. 2 shows an example diagram depicting an exchange of a boot policy between the management system and the server.

FIG. 3 shows an example flow chart depicting operations performed by the management system and the server for determining a priority boot order for boot devices.

FIG. 4 shows an example flow chart depicting enhanced or optimized boot operations performed by the server to load or boot an operating system of the server.

## DESCRIPTION OF EXAMPLE EMBODIMENTS

## Overview

Techniques are provided herein for optimizing boot order for devices in a data center environment. These techniques may be embodied as a method, apparatus and instructions in a computer-readable storage media to perform the method. A computing apparatus having connectivity to a network receives instructions from a management device in the network. The instructions comprise attributes that are associated with boot devices hosted by the computing apparatus. The attributes are analyzed to determine a priority order for the boot devices. One or more boot devices hosted by the computing apparatus is removed from an initialization process when the one or more boot devices do not match the attributes in the instructions. The remaining boot devices, 55  
other than the one or more boot device removed from the initialization process, are initialized in accordance with the priority order.

## Example Embodiments

The techniques described herein relate to optimizing a boot order for data center devices. An example data center environment (e.g., “data center”) 100 is illustrated in FIG. 1. The data center 100 has a management system device (“management system”) shown at reference numeral 102. The data center 100 also has a server device (“server”) 65

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shown at reference numeral 104. The management system 102 and the server 104 are configured to communicate with each other via a network (e.g., a wide area network (WAN) or local area network (LAN)), shown at reference numeral 106.

The management system 102 comprises a management application shown at reference numeral 108. The management application 108 may be a software or a hardware (e.g., an application specific integrated circuit (ASIC)) component of the management system 102. The management system 102 also has a storage unit (e.g., “storage”) 110 that stores server profile information in the form of server type service profiles 111(1)-111(n) associated with different servers in the data center 100 with which the management system 102 15  
communicates. For example, the storage 110 may be a memory component of the management system 102 that stores server profile information associated with a plurality of different types of servers, e.g., server type 1 service profile 111(1) to server type N service profile 111(N) in the data center 100. It should also be understood that the data center 100 may comprise other servers, and for simplicity, only one server is shown.

The management system 102 utilizes the management application 108 and the server profile information stored in the storage 110 to generate server management policies. As shown at reference 105 in FIG. 1, the server management policies are sent from the management system 102 to the server 104 across the network 106. The server 104 is configured to receive the server management policies from the management system 102, and the server 104 analyzes the server management policies to optimize the boot order control of devices that are operated by the server 104.

The management system 102 is configured to generate server management policies that are sent to the server 104. The server 104 receives the server management policies from the management system 102 in order to optimize boot order control, as described herein. The server 104 comprises several components. For example, as shown in FIG. 1, the server 104 has a network interface unit 112, a processor 114, a memory 116, a basic input/output system (BIOS) 118 and boot devices 120. Additionally, the server 104 has an optional read only memory (ROM) unit 122.

In general, the network interface unit 112 is configured to receive the server management policies from the management system 102 across the network 106. The processor 114 evaluates the management policies and utilizes the boot device enumeration process logic 124 in the memory 116 to optimize the boot order control of the boot devices 120, as described herein. The memory 116 also has a server manager database (“server manager”) 126 to store boot order instructions. In one example, the boot device enumeration process logic 124 comprises executable instructions that when executed by the processor 114, cause the processor 114 to access the BIOS 118 to turn on or “boot” one or more of the boot devices 120 in accordance with the management policies that are received from the management system 102 in order to ultimately boot or load an operating system. Thus, in one example of the techniques presented herein, the management policies generated by the management system 102 and received by the server 104 set forth instructions that are utilized by the server 104 to optimize and prioritize the boot order of the boot devices 120 to load the operating system of the server 104.

The boot devices 120 in FIG. 1 may represent one or more devices that are controlled or hosted by the server 104. For example, the boot devices 120 may belong to one or more “boot device types.” The boot device types may designate a

group or family of particular devices. In one example, the boot devices **120** may include a hard disk drive (HDD) device type, a floppy disk drive (FDD) device type, a compact disc ROM (CD-ROM) device type, etc. Each of these device type groups may comprise several specific devices. For example, the HDD device type may comprise local disks, storage area networks (SANs), Internet Small Computer System Interfaces (ISCSIs), Universal Serial Buses (USBs), Secure Digital (SD) cards, etc. A floppy disk drive (FDD) device type may comprise, for example, a USB floppy disk drive, and a CD-ROM device type may comprise optical CD drives (e.g., a CD-read (CD-R) drive, a CD-read/write (CD-RW) drive, etc.). The devices in each device type may be enumerated in a particular order in a boot list stored by the server **104** (e.g., in the server manager **126**).

Currently, when a server is powered on and begins to operate, the BIOS of the server instructs the server's processor to load or boot devices. However, current booting techniques allow the processor to order and re-order only the device types or groups and not the particular devices within the device types or groups. Thus, as the processor is instructed to perform reboot operations, the processor may reboot all of the particular devices that are enumerated in the device type. For example, the BIOS of the server may specify a reboot order for device types as follows:

[HDD]→[FDD]→[CD-ROM]

and particular devices in each device type (i.e., devices enumerated as HDD devices, FDD devices and CD-ROM devices) will be rebooted by the processor based on the order in which they are enumerated. Thus, in certain situations, particular devices that are intended to be rebooted may be skipped or ordered in a lower priority than intended. For example, if a server needs to reboot through a local disk, and if a SAN device is enumerated ahead of the local disk in the HDD device enumeration, the SAN device would be selected first in the HDD category. Additionally, in one example, only the SAN device may become part of the final boot device list (possibly excluding the local disk from the boot list altogether). As stated above, this is problematic because essential and/or intended devices may be entirely skipped from the boot list.

The techniques described herein resolve these shortcomings by providing flexible and stateless information to a server that allows the server to select the correct set of devices to boot. In particular, the management system **102** sends server management policies to the server **104** that contains information that the server **104** intelligently parses to enumerate only required devices to boot.

Referring back to FIG. 1, it is to be appreciated that the server **104** has the network interface unit **112** that is coupled to the processor **114**. The network interface unit is configured to receive the server management policies (including the boot policy **202**) from the management system **102**. The processor **114** is, for example, a microprocessor or microcontroller that is configured to execute program logic instructions (i.e., software) for carrying out various operations and tasks described above. For example, the processor **114** is configured to execute boot device enumeration process logic **124** to enhance and optimize boot order control by enumerating necessary boot devices. The functions of the processor **114** may be implemented by logic encoded in one or more tangible computer readable storage media or devices (e.g., storage devices, compact discs, digital video discs, flash memory drives, etc. and embedded logic such as an ASIC, digital signal processor instructions, software that is executed by a processor, etc.).

The memory **116** may comprise read only memory (ROM), random access memory (RAM), magnetic disk storage media devices, optical storage media devices, flash memory devices, electrical, optical, or other physical/tangible (non-transitory) memory storage devices. The memory **116** stores software instructions for the boot device enumeration process logic **124**. The memory **116** also stores the server manager **126** that, for example, stores the boot order of the server **104**. Thus, in general, memory **116** may comprise one or more computer readable storage media (e.g., a memory storage device) encoded with software comprising computer executable instructions and when the software is executed (e.g., by the processor **114**), it is operable to perform the operations described above for the boot device enumeration process logic **124**.

The boot device enumeration process logic **124** may take any of a variety of forms, so as to be encoded in one or more tangible computer readable memory media or storage devices for execution, such as fixed logic or programmable logic (e.g., software/computer instructions executed by a processor). The processor **114** may be an ASIC that comprises fixed digital logic, or a combination thereof.

For example, the processor **114** may be embodied by digital logic gates in a fixed or programmable digital logic integrated circuit, which digital logic gates are configured to perform the boot device enumeration process logic **124**. In general, the boot device enumeration process logic **124** may be embodied in one or more computer readable storage media encoded with software comprising computer executable instructions and when the software is executed operable to perform the operations described hereinafter.

Reference is now made to FIG. 2. FIG. 2 shows a diagram depicting an example exchange **200** of a boot policy between the management system **102** and the server **104**. In particular, FIG. 2 shows a server profile **111(1)**, for example, that is stored in the storage unit **110** of the management system **102**. The service profile **111(1)** may be any of the service profiles shown in FIG. 1, and it should be appreciated that the server profile **111(1)** corresponds to the service profile that is associated with the server **104**. The service profile **111(1)** has several policies that are associated with the server **104**. In one example, one or more of the policies may be sent to the server **104** as a part of the server management policies sent to the server **104**, shown in FIG. 1 above. In particular, the service profile **111(1)** has a boot policy **202** that is sent to the server **104**. The boot policy **202** has boot order instructions that comprise attributes associated with the boot devices hosted by the server **104**. It should be appreciated that the boot policy **202** may comprise instructions in the form of a data structure that indicates the boot priority order for particular device types. Upon receiving the boot policy **202** (e.g., as part of the server management policies exchanged between the management system **102** and the server **104**), the server **104** analyzes the attributes in the instructions to determine a priority order for the boot devices. For example, as shown in FIG. 2, the boot policy **202** is analyzed by the server **104** to determine the boot order **203**:

1. Boot from SAN (using a Virtual Host Bus Adapter (vHBA)).
  2. Boot from a Pre-Boot Execution Environment (using a Virtual Network Interface Card (vNIC)).
  3. Boot from a local HDD.
  4. Boot from a USB CD.
- It should be appreciated that the service profile **111(1)** may also comprise, among other policies, a discovery policy **204**, a BIOS policy **206** and a maintenance policy **208**.

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Reference is now made to FIG. 3. FIG. 3 shows an example flow chart 300 depicting operations performed by the management system 102 and the server 104 for determining a priority order for boot devices. At operation 302, a user defines a boot policy in the management system 102 and provisions the server 104 accordingly. Management software of the management system 102 implicitly adds attributes to the boot policy 202 that allows the server 104 (e.g., firmware in the server 104) to identify the particular boot devices. The attributes may have boot connection vector (BCV) attributes and/or bootstrap entry vector (BEV) attributes that are associated with boot devices hosted by the server. In one example, the management software of the management system 102 adds a World Wide Port Name (WWPN) to identify a vHBA or Media Access Control (MAC) address of a vNIC.

At operation 304, the server 104 (e.g., the firmware of the server 104) masks out or removes devices hosted by the server 104 from an initialization process that do not match the boot device parameters or attributes set forth in the boot policy 202. At operation 306, the server 104 loads firmware (e.g., ROM firmware) only for those devices that match the boot device parameters or attributes in the boot policy 202, and at operation 308, the server 104 initializes these devices. When the server 104 initializes these devices, the server 104 may select a first one of the boot devices that belongs to a first device type that has a first priority in the priority order (e.g., a particular device in the HDD device type group). This first device is instructed to initialize. Likewise, the server 104 may then select a second one of the boot devices that belongs to a second device type that has a second priority in the priority order (e.g., a particular device in the FDD device type group). This second device is then instructed to initialize. At operation 310, the server 104 loads a computer device operating system using one or more of the boot devices that matches the boot device parameters or attributes in the boot policy 202. Once the operating system has been loaded, the server 104 may then terminate initialization of other boot devices.

Reference is now made to FIG. 4. FIG. 4 illustrates an example flow chart 400 that shows enhanced or optimized booting operations performed by the server 104 to load an operating system of the server 104. At operation 402, the server 102 powers on, and at operation 404, the server 104 starts a power on self-test. The server 104 then reads boot device parameters (or attributes) at operation 406 from, for example, the boot policy 202 received as a part of the server management policies described above. At operation 408, the boot devices are enumerated in a boot list according to the boot device parameters provided in the boot policy 202. The server 104 evaluates, at operation 410, the boot list to determine whether the next device (or in an initial case, the first device) is valid (e.g., whether the device matches the parameters provided in the boot policy). If not, the server 104, at operation 412, logs the boot device information and boot failure information into a system event log (SEL) of the server 104. If so (i.e., if the answer to operation 410 is "yes"), at operation 412, the server 104 obtains BEV and/or BCV attributes for the next device in the enumeration in the boot list. At operation 416, the server then boots the next device using the BEV or BCV attributes. The server 104 then determines, at operation 418, whether the operating system has been booted. If the operating system has not been booted, the server reverts to operation 410 to evaluate the next device in the boot list. If so, the boot device reverts to

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operation 412 to log the boot device/boot failure information into the SEL. At operation 420, the server 104 exits the power on self-test.

Thus, by the above techniques, boot order control is maintained at a centralized management entity (e.g., the management system 102), and stateless boot order instructions are provided to the server 104. The techniques described above avoid unintended device initialization code from executing during a server power on mode, thereby reducing the time to boot the operating system. In other words, the techniques described above allow the server 104 to accomplish enhanced or optimized booting control by enumerating only necessary devices to boot. As a result, the reboot time of the server 104 is reduced.

It should be appreciated that the techniques described above in connection with all embodiments may be performed by one or more computer readable storage media that is encoded with software comprising computer executable instructions to perform the methods and steps described herein. For example, the operations performed by the management system 102 and the server 104 may be performed by one or more computer or machine readable storage media (non-transitory) or device executed by a processor and comprising software, hardware or a combination of software and hardware to perform the techniques described herein.

In summary, a method is provided comprising: at a computing apparatus device having connectivity to a network, receiving instructions from a management device in the network, wherein the instructions comprise attributes associated with boot devices hosted by the computing apparatus; analyzing the attributes in the instructions to determine a priority order for the boot devices; removing one or more boot devices hosted by the computing apparatus device from an initialization process when the one or more boot devices do not match the attributes in the instructions; and initializing remaining boot devices other than the one or more boot devices removed from the initialization process such that the remaining boot devices are initialized in accordance with the priority order.

In addition, an apparatus is provided comprising: a network interface unit; a memory; and a processor coupled to the network interface unit and the memory, the processor being configured to: receive instructions from a management device in a network, wherein the instructions comprise attributes associated with boot devices; analyze the attributes in the instructions to determine a priority order for the boot devices; remove one or more boot devices from an initialization process when the one or more boot devices do not match the attributes in the instructions; and initialize remaining boot devices other than the one or more boot devices removed from the initialization process such that the remaining boot devices are initialized in accordance with the priority order.

Furthermore, these techniques may be embodied in another form in which one or more computer readable storage media is encoded with software comprising computer executable instructions and when the software is executed operable to: receive instructions from a management device in a network, wherein the instructions comprise attributes associated with boot devices hosted by a computing apparatus; analyze the attributes in the instructions to determine a priority order for the boot devices; remove one or more boot devices hosted by the computing apparatus from an initialization process when the one or more boot devices do not match the attributes in the instructions; and initialize remaining boot devices other than the one or more

boot devices removed from the initialization process such that the remaining boot devices are initialized in accordance with the priority order.

The above description is intended by way of example only. Various modifications and structural changes may be made therein without departing from the scope of the concepts described herein and within the scope and range of equivalents of the claims.

What is claimed is:

1. A method comprising:

at a computing apparatus having connectivity to a network, receiving instructions from a management device in the network, wherein the instructions comprise attributes associated with boot devices of one or more device types hosted by the computing apparatus;

analyzing the attributes in the instructions to determine a priority order for the boot devices, wherein the priority order assigns each boot device a priority and the computing apparatus is configured to assign different priorities to boot devices within the same device type; removing one or more boot devices hosted by the computing apparatus that do not match the attributes in the instructions from an initialization process;

generating a list of the included boot devices that were not removed; and

initializing remaining boot devices other than the one or more boot devices removed from the initialization process such that the remaining boot devices are initialized in accordance with the priority order without attempting to initialize removed boot devices.

2. The method of claim 1, wherein receiving comprises receiving the instructions in the form of a data structure that indicates the priority order.

3. The method of claim 1, wherein initializing comprises: selecting a first one of the remaining boot devices that belongs to a first device type that has a first priority in the priority order;

instructing the first one of the remaining boot devices to initialize;

selecting a second one of the remaining boot devices that belongs to a second device type that has a second priority in the boot order; and

instructing the second one of the remaining boot devices to initialize.

4. The method of claim 1, further comprising loading an operating system of a processor of the computing apparatus using one or more of the initialized boot devices.

5. The method of claim 4, further comprising terminating the initialization of other boot devices when the operating system has been loaded.

6. The method of claim 1, wherein the attributes include boot connection vector (BCV) attributes or bootstrap entry vector (BEV) attributes associated with the boot devices hosted by the computing apparatus.

7. The method of claim 6, further comprising analyzing the BCV attributes or the BEV attributes to determine the priority for initializing the boot devices.

8. An apparatus comprising:

a network interface unit;

a memory; and

a processor coupled to the network interface unit and the memory, and configured to:

receive instructions from a management device in a network, wherein the instructions comprise attributes associated with boot devices of one or more device types;

analyze the attributes in the instructions to determine a priority order for the boot devices, wherein the priority order assigns each boot device a priority and the processor is configured to assign different priorities to boot devices within the same device type;

remove one or more boot devices that do not match the attributes in the instructions from an initialization process;

generate a list of the included boot devices that were not removed; and

initialize remaining boot devices other than the one or more boot devices removed from the initialization process such that the remaining boot devices are initialized in accordance with the priority order without attempting to initialize removed boot devices.

9. The apparatus of claim 8, wherein the processor is further configured to receive the instructions in the form of a data structure that indicates the priority order.

10. The apparatus of claim 8, wherein the processor is further configured to:

select a first one of the remaining boot devices that belongs to a first device type that has a first priority in the priority order;

instruct the first one of the remaining boot devices to initialize;

select a second one of the remaining boot devices that belongs to a second device type that has a second priority in the boot order; and

instruct the second one of the remaining boot devices to initialize.

11. The apparatus of claim 8, wherein the processor is further configured to load an operating system using one or more of the initialized boot devices.

12. The apparatus of claim 11, wherein the processor is further configured to terminate the initialization of other boot devices when the operating system has been loaded.

13. The apparatus of claim 8, wherein the attributes include boot connection vector (BCV) attributes or bootstrap entry vector (BEV) attributes associated with the boot devices.

14. The apparatus of claim 13, wherein the processor is further configured to analyze the BCV attributes or the BEV attributes to determine the priority for initializing the boot devices.

15. A computer-readable storage media encoded with software comprising computer executable instructions and when the software is executed operable to:

receive instructions from a management device in a network, wherein the instructions comprise attributes associated with boot devices of one or more device types hosted by a computing apparatus;

analyze the attributes in the instructions to determine a priority order for the boot devices, wherein the priority order assigns each boot device a priority and the software is operable to assign different priorities to boot devices within the same device type;

remove one or more boot devices hosted by the computing apparatus that do not match the attributes in the instructions from an initialization process;

generate a list of the included boot devices that were not removed; and

initialize remaining boot devices other than the one or more boot devices removed from the initialization process such that the remaining boot devices are initialized in accordance with the priority order without attempting to initialize removed boot devices.

16. The computer-readable storage media of claim 15, wherein the instructions operable to receive comprise instructions operable to receive the instructions in the form of a data a structure that indicates the priority order.

17. The computer-readable storage media of claim 15, 5 wherein the instructions operable to initialize comprise instructions operable to:

select a first one of the remaining boot devices that belongs to a first device type that has a first priority in the priority order; 10

instruct the first one of the remaining boot devices to initialize;

select a second one of the remaining boot devices that belongs to a second device type that has a second priority in the boot order; and 15

instruct the second one of the remaining boot devices to initialize.

18. The computer-readable storage media of claim 15, further comprising instructions operable to load an operating system using one or more of the initialized boot devices. 20

19. The computer-readable storage media of claim 18, further comprising instructions operable to terminate the initialization of other boot devices when the operating system has been loaded.

20. The computer-readable storage media of claim 15, 25 wherein the attributes include boot connection vector (BCV) attributes or bootstrap entry vector (BEV) attributes associated with the boot devices hosted by the computing apparatus.

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